FEEDING HABITS OF MEDITERRANEAN HORSE MACKEREL, *TRACHURUS MEDITERRANEUS* (CARANGIDAE), IN THE CENTRAL ADRIATIC SEA

by

Mate ŠANTIĆ (1), Ivan JARDAS (2) & Armin PALLAORO (2)

ABSTRACT. - The feeding habits of the Mediterranean horse mackerel, *Trachurus mediterraneus* from the central Adriatic Sea, were investigated with respect to fish size and seasons. Stomach contents of 1200 specimens, 11.6 - 38.0 cm TL, taken at monthly intervals (January-December, 1996) were analyzed. Of the total number of stomachs examined, 606 were empty (50.5%). The proportion of empty stomachs varied significantly among size classes and seasons. Maximum feeding intensity occurred during the summer and in size class > 32.2 cm TL. The food composition suggests that the Mediterranean horse mackerel is a carnivorous species. A total of 29 different prey species belonging to six animal groups were identified in stomach contents: Crustacea (Euphausiacea, Mysidacea, Decapoda), Teleostei, Cephalopoda and Polychaeta. Euphausiacea were the most important ingested prey (%IRI = 90.1), especially in small and medium size classes (up to 28 cm TL). At the species level, euphausiids *Nyctiphanes couchii* (%IRI = 69.7) and *Euphausia krohni* (%IRI = 16.4) were the most frequent prey. Teleosts, whose proportion increased in large size classes, were secondary food (%IRI = 9.1), while other animal groups were considered as occasional food. The mean weight of stomach contents increased significantly for fish larger than 26.1 cm TL, while mean number of prey items did not differ among the size classes. There was little seasonal variation in food composition. Euphausiids were dominant prey during all seasons, and were especially abundant from summer to winter.

RÉSUMÉ. - Régime alimentaire du chinchard Méditerranéen à queue jaune, *Trachurus mediteranneus* (Carangidae), en mer Adriatique centrale.

Le régime alimentaire de *Trachurus mediterraneus* a été étudié dans l'Adriatique centrale en fonction de la taille des poissons et de la saison. Les contenus stomacaux de 1200 individus, 11,6 - 38,0 cm TL, capturés avec une périodicité mensuelle (janvier-décembre 1996) ont été analysés. Un total de 606 estomacs étaient vides (50,5%). La proportion des estomacs vides a varié selon les classes de taille et la saison. Le maximum d'intensité alimentaire a été observé en été et pour des tailles supérieures à 32,2 cm TL. La composition des proies suggère que le chinchard à queue jaune est carnivore. Au minimum 29 espèces de proies ont été répertoriées, réparties en 6 principaux groupes : les Crustacés (Euphausiaceae, Mysidaceae, Décapodes), les Poissons, les Céphalopodes et les Annélides polychètes. Les Euphausiaceae ont représenté la nourriture principale (%IRI = 90,1) surtout parmi les classes de taille inférieures à 28 cm. Au niveau spécifique, les Euphausiaceae *Nyctiphanes couchii* (%IRI = 69,7) et *Euphausia krohni* (%IRI = 16,4) ont été les plus fréquents. Les poissons, dont la part a augmenté pour les grandes classes de taille, forment les proies secondaires (%IRI = 9,1), alors que les autres groupes constituent une nourriture accidentelle. Les poids moyens des contenus stomacaux augmentent chez les poissons de taille supérieure à 26 cm. Un léger changement du régime alimentaire en fonction de la saison a été mis en évidence.

Key words. - Carangidae - *Trachurus mediterraneus* - MED - Adriatic Sea - Feeding habits.

Members of *Trachurus* genus (Perciformes, Carangidae) are common and widely distributed in the Mediterranean (Smith-Vaniz, 1986). In the Adriatic Sea this genus is represented by three species: Atlantic horse mackerel, *T. trachurus* (Linnaeus), Mediterranean horse mackerel, *T. mediterraneus* (Steindachner) and blue jack mackerel, *T. picturatus* (Bowdich). Mediterranean horse mackerel is a schooling semi-pelagic species, most commonly found at about 20-200 m depth (Jardas, 1996). It spawns in spring-summer (Arneri, 1984; Arneri and Tangerini, 1984). There is no reliable statistical data on *T. mediterraneus* landings in the eastern Adriatic, but annual catch can be tentatively estimated at around 400 tons (FAO, 2000). In the Mediterranean, this species is of major importance in the pelagic and demersal fisheries and annual landings fluctuated from 5,120 to 109,560 tons in a period from 1989 to 1998 (FAO, 2000). Presently, this species is still abundant in the Adriatic Sea, comparing to other economically important species that are currently considered to be over fished (Vrgoč, 2000). However, despite its abundance, very little is known about the trophic ecology of the *T. mediterraneus* in the Adriatic. Literature review shows that descriptions of the *T. mediterraneus* diet in the Adriatic deal only with quantitative aspects of the diet. Lipskaja (1966) reported that *T. mediter-*

(1) Faculty of Natural Science and Mathematics, University of Split, Teslina 12, 21000 Split, CROATIA. [msantic@pmfst.hr]

(2) Institute of Oceanography and Fisheries, Šet. I. Meštrovića 63, 21000 Split, CROATIA. [jardas@izor.hr, pallaoro@izor.hr]

raneus living in the Albanian waters feed in summer with different developmental stages of fish and crustaceans such as amphipods, mysids and decapods. Bini (1968) noted that diet of this species in Italian waters consists of planktonic crustaceans and larvae, juveniles and adults of different teleosts, especially of anchovy and clupeids. Tortonese (1975) shortly reports that *Trachurus* species in Italian waters feeds on fish and crustaceans. The literature referring to other regions is also not very extensive. Ben-Salem (1988) had similar results in his study on *T. mediterraneus* from the Mediterranean and North-eastern Atlantic. Finally, Kyrtatos (1998) revealed that in the Aegean Sea larvae and postlarvae of teleosts formed the dominant prey of *T. mediterraneus*, followed by crustaceans (copepods and mysids).

This study gives detailed data about the food and feeding habits of *T. mediterraneus* in the Adriatic Sea analyzing quantitative variations in its composition and intensity of feeding with regard to factors such as seasonality and fish size.

MATERIAL AND METHODS

Samples of Mediterranean horse mackerel were taken from five localities in the central Adriatic placed at continental shelf mostly at depths from 90 to 140 m (Fig. 1). Random samples were taken from commercial bottom-trawl catches taken with a cod-end of 22 mm stretched mesh size. Materials were hauled three times a day; the first haul lasted from 4 to 10 a.m., second from 11 a.m. to 4 p.m., and third from 5 to 10 p.m. Monthly samples were collected from January to December 1996 and a total of 1200 specimens (100 specimens per month) were analyzed. Total length (TL) of fish examined was measured to the nearest 0.1 cm and weight to the nearest 0.1 g. Immediately after capture, fish were dissected and gut removed and preserved in 4% formalin solution, to prevent further food digestion. In the laboratory, identification of prey was carried out to the species level whenever possible. Species abundance and wet weight, to the nearest 0.001 g after removal of surface water by blotting on tissue paper, were recorded.

Total length of fish examined ranged from 11.6 to 38.0 cm ($x = 23.97 \pm 4.89$ cm). In order to evaluate variation in food habits with growth, specimens from 16.2 to 32.1 cm were separated into eight two-centimeters size classes according to their total length. Due to small sample size other specimens were grouped into the following size ranges: < 16.1 cm (N = 69) and > 32.2 cm (N = 65). The number of specimens analyzed per size-class ranged from 65 to 241.

Numerous indices have been described for quantitatively expressing the importance of different prey in the diets of fish (Berg, 1979; Hyslop, 1980). Those used in the present study were:

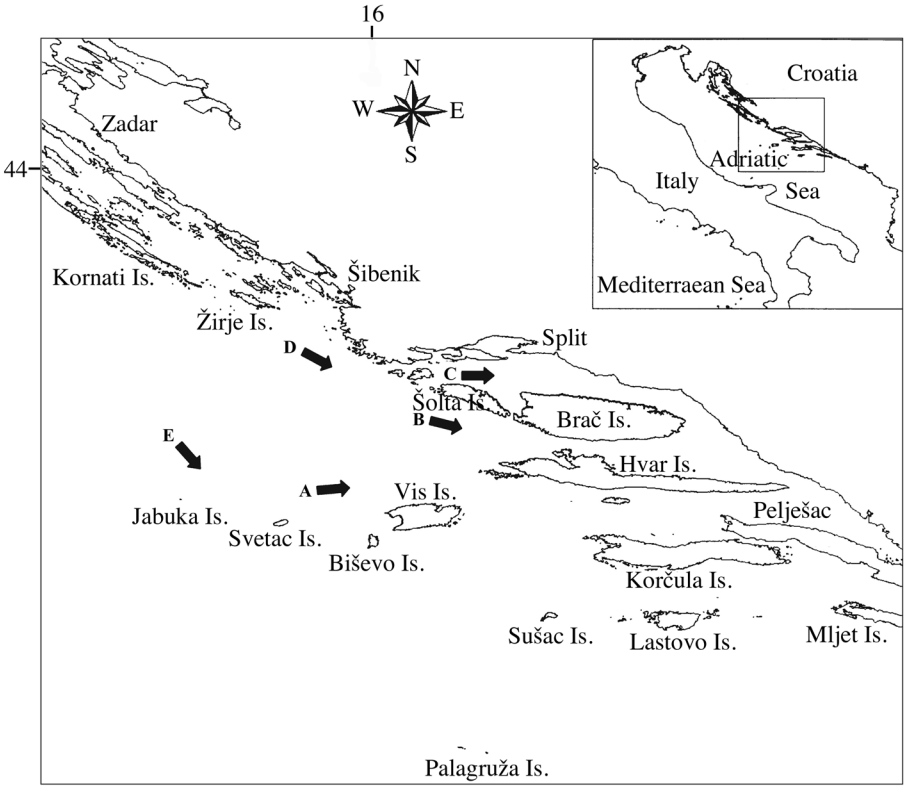

Figure 1. - Study area and sampling localities of *Trachurus mediterraneus* in the central Adriatic. A: near islands Vis and Svetac; B: south off Maslenica; C: Split Channel; D: Blitvenica fishing area; E: Islands of Jabuka.

Vacuity index (VI) *i.e.,* number of empty stomachs divided by total number of stomachs multiplied by 100;

Percentage frequency of occurrence (%F), based on the number of stomachs in which a food item was found, expressed as the percentage of total number of non-empty stomachs; the percentage of numerical abundance (%Cn) *i.e.,* the number of each prey item in all non-empty stomachs, expressed as the percentage of total number of food items in all stomachs in a sample; and the percentage gravimetric composition (%Cw) *i.e.,* the wet weight of each prey item, expressed as the percentage of total weight of stomach contents in a sample.

The main food items were identified using the index of relative importance (IRI) of Pinkas *et al*. (1971), as modified by Hacunda (1981):

$$IRI = \%F \times (\%Cn + \%Cw)$$

This index has been expressed as:

$$\%IRI = (IRI / \sum IRI) \times 100$$

Prey species were sorted in decreasing order according to their percentage IRI contribution and then cumulative %IRI was calculated.

Statistical differences ($p < 0.05$) in diet composition with respect to size and season, were assessed by a chi-square test (Sokal and Rohlf, 1981), applied on the frequency of a given prey. The variation of vacuity index was also tested by a chi-square test. The significance of variation of mean number (Nm/ST) of prey items and mean weight per stomach (Wm/ST) among size classes and seasons was tested by analysis of variance (ANOVA) while Tukey's test was employed to locate the source of any difference (Zar, 1984).

RESULTS

Feeding intensity

Of the 1200 stomachs of Mediterranean horse mackerel examined, 606 were empty (50.5%). The proportion of empty stomachs varied significantly among the size classes of fish examined ($\chi^2 = 19.0$, $p < 0.05$), with a maximum of 67.1% (size class 16.2-18.1 cm) and minimum of 30.7% (size class > 32.2 cm) (Fig. 2). This proportion also varied significantly within the year ($\chi^2 = 31.3$, $p < 0.05$), with a maximum of 66.0% during the winter. Minimum proportion of empty stomachs was found in summer (35.3%), while in samples collected in spring and autumn proportion of empty stomachs was 54.3% and 45.0% respectively.

Diet composition

A total of 29 different prey species belonging to six major taxa: Teleostei, Euphausiacea, Mysidacea, Decapoda, Cephalopoda and Polychaeta were identified from stomach contents. Table I shows the frequency of occurrence, numerical and biomass composition and the Index of Relative Importance of different prey groups and prey species found in stomachs. Euphausiids were the most important ingested prey, constituting 90.1% of the total IRI, followed by various development stages of pelagic and demersal fish species (%IRI = 9.1). Other taxa found in the stomach contents (Mysidacea, Decapoda, Cephalopoda and Polychaeta) were less important as prey items. At the species level two euphausiids: *Nyctiphanes couchii* (%IRI = 69.7) and *Euphausia krohni* (%IRI = 16.4) followed by three teleosts: *Gadiculus argenteus* (%IRI = 3.3), *Maurolicus muelleri* (%IRI = 2.6) and *Engraulis encrasicolus* (%IRI = 1.3) were the most frequent prey.

Food in relation to fish size

Diet composition for size classes with regard to the cumulative percentage IRI of the six main prey groups is shown in figure 3. Euphausiids and teleosts are the only prey groups present in the diet of all size classes. Euphausiids were the most important prey group in small and medium size classes up to 28.1 cm TL, while contributions of mysids, and earlier development stages of teleosts were comparatively low. It must be noted that the frequency of euphausiids significantly decreased with increasing size ($\chi^2 = 43.8$, $p < 0.05$), whereas the frequency of teleosts significantly increased ($\chi^2 = 34.8$, $p < 0.05$). In the largest size class (> 32.2 cm), teleosts represented 58.0% of total IRI. Other prey groups i.e., decapods, cephalopods and polychaeta, occurred in stomachs of specimens belonging to medium and large size classes.

The total amount of food ingested, as shown by the mean weight of stomach contents (Wm/ST), varied significantly among size classes ($F = 60.2$, $p < 0.05$). Tukey's test revealed that mean weight of stomach contents for specimens in length classes > 26.1 cm TL significantly differed from others (Fig. 4). The mean number of prey (Nm/ST) increased with increasing size up to the 26.2-28.1 cm class, and then

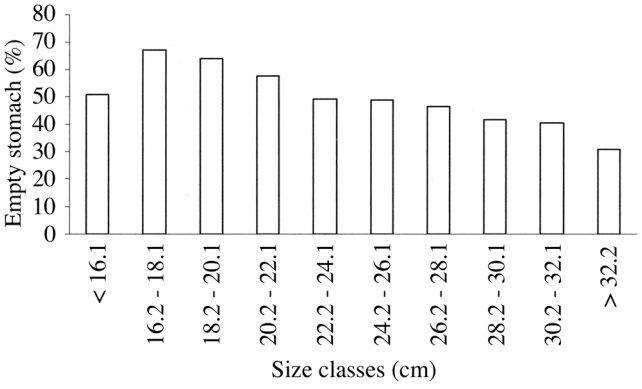

Figure 2. - Variation in percentage of empty stomachs for *Trachurus mediteranneus* as function of body size.

Table I. - Diet composition of 594 *Trachurus mediterraneus*. %F: Frequency of occurrence; %Cn: Percentage of numerical composition; %Cw: Percentage of gravimetric composition; IRI: Index of relative importance. Only prey species with a contribution to the %IRI of more than 0.1 are listed. + = < 0.1%.

Food items	(%F)	(%Cn)	(%Cw)	IRI	%IRI
TELEOSTEI					
Gadiculus argenteus	6.73	0.46	14.55	101.01	3.30
Maurolicus muelleri	6.06	0.69	12.83	81.93	2.67
Engraulis encrasicolus	6.56	0.79	5.46	41.00	1.33
Lesueurigobius friesii	2.35	0.15	2.29	5.73	0.18
Helicolenus dactylopterus	1.01	0.056	5.20	5.30	0.17
Arnoglossus laterna	1.17	0.08	2.40	2.90	+
Sardina pilchardus	1.51	0.06	1.63	2.55	+
Aphia minuta	1.01	0.07	0.89	0.96	+
Phycis blennoides	0.50	0.018	1.41	0.71	+
Belone belone	0.50	0.03	1.32	0.67	+
Trisopterus minutus capelanus	0.50	0.037	0.83	0.43	+
Lepidopus caudatus	0.16	0.018	2.05	0.33	+
Scorpaena porcus	0.50	0.018	0.54	0.27	+
Scomber scombrus	0.33	0.016	0.21	0.07	+
Merluccius merluccius	0.16	0.006	0.27	0.04	+
Trigla lyra	0.16	0.006	0.19	0.03	+
Phycis phycis	0.16	0.007	0.13	0.02	+
Boops boops	0.16	0.006	0.08	0.01	+
Conger conger	0.16	0.006	0.07	0.01	+
Non-identified Teleostei	13.37	0.35	2.34	35.96	1.17
Total Teleostei	5.06	0.42	54.68	279.93	9.14
CRUSTACEA					
Euphausiacea					
Nyctiphanes couchii	29.46	52.94	19.46	2132.9	69.7
Euphausia krohni	14.30	25.62	9.53	502.6	16.4
Meganyctiphanes norvegica	8.24	4.65	3.36	66.0	2.15
Non-identified Euphausiacea	7.07	6.22	1.73	56.2	1.83
Total Euphausiacea	22.32	89.43	34.08	2757.7	9.14
Mysidacea					
Lophogaster typicus	1.51	5.75	2.14	11.9	0.38
Decapoda					
Parapenaeus longirostris	2.18	0.13	1.86	4.33	0.14
Munida rugosa	1.01	0.043	1.16	1.21	+
Penaeus kerathurus	0.50	0.043	0.66	0.35	+
Processa edulis	0.84	0.068	0.28	0.29	+
Non-identified Decapoda	1.34	0.074	0.71	1.05	+
Total Decapoda	1.43	0.358	4.67	7.23	0.23
CEPHALOPODA					
Illex illecebrosus	0.67	0.037	2.33	1.58	+
Sepiola sp.	1.01	0.037	0.96	1.00	+
Total Cephalopoda	0.76	0.074	3.29	2.58	+
POLYCHAETA					
Non-identified Polychaeta	0.67	0.12	0.95	0.71	+

declined (Fig. 4). However those changes were not significant (ANOVA, $F = 1.54$, $p > 0.05$).

Seasonal variation in the diet composition

There was a little seasonal variation in food habits of *T. mediterraneus* within the studied area (Fig. 5). Euphausiids were the dominant prey group during all seasons, particularly from summer to winter (%IRI > 70). Teleosts were also present in the diet throughout the year, with a peak value recorded in spring (%IRI = 46.0). Decapods, mysids and cephalopods were present in the contents during all seasons, while polychaeta were only found in autumn-winter period. Significant differences among seasons were found for euphausiids ($\chi^2 = 30.5$, $p < 0.05$), and teleosts ($\chi^2 = 12.7$, $p < 0.05$) while no significant seasonal differences were found for the other prey items, i.e., decapods ($\chi^2 = 1.23$, $p < 0.05$), cephalopods ($\chi^2 = 0.40$, $p < 0.05$), and mysids ($\chi^2 = 0.97$, $p < 0.05$).

Both, the mean weight (Wm/ST) and mean number of prey items per stomach (Nm/ST) showed little differences during the year (Fig. 6). Mean weight (Wm/ST) increased from winter to autumn, but not significantly ($F = 1.42$, $p > 0.05$). Also, Nm/ST values showed a tendency to increase from winter to summer season, but not significantly ($F = 2.55$, $p > 0.05$).

DISCUSSION

Our study indicates that the Mediterranean horse mackerel is mostly planktophagous, as are all species of the genus *Trachurus* (Cousseau, 1967; Konchina, 1981; Hecht, 1990; Olaso *et al*., 1999). According to our data, its main prey items were plankton euphausiids *Nyctiphanes couchii, Euphausia krohni* and less common *Meganyctiphanes norvegica*. The prey group that represents 50% or more of total IRI, can be classified as main food (Rosecchi and Nouaze, 1987). Teleosts, such as *Gadiculus argenteus*, *Maurolicus muelleri* and *Engraulis encrasicolus* and some others were less important in the diet, except in the large size classes exceeding 28 cm TL, and can therefore be considered as secondary food. Other prey groups, *i.e*. mysids, decapods, cephalopods and polychaeta, were of minor importance and thereby considered as occasional food.

Euphausiids are present in southern and deepest parts of central Adriatic, while in northern shallow waters this group is not present. The number of species increases from central to southern Adriatic and from coast to the open sea (Šipoš, 1977). Besides the Mediterranean horse mackerel, euphausiids are also significant source of food for few other Adriatic teleosts, including *Merluccius merluccius*, *Micromesistius poutassou*, *Scomber scomber* and *Sardina pilchardus* (Karlovac, 1959; Hoenigman, 1963; Županović, 1968; Jukić, 1978). Euphausiid species *Nyctiphanes couchii* and *Euphausia krohni* are commonly present in the zooplankton

samples from central Adriatic, especially in the area of island Vis, Jabuka pit and Blitvenica fishing area, while *Meganyctiphanes norvegica* is more frequent in the South Adriatic Pit (Šipoš, 1977; Gamulin, 1979; Nožina, 1979). Different distribution patterns are probably the reason why the two first mentioned euphausiid species are more abundant in the Mediterranean horse mackerel stomachs from central Adriatic than *Meganyctiphanes norvegica*. In the south Adriatic the most common euphausiids are *Euphausia hemigiba*, *Stylocherion abbreviatum* and *Stylocherion maximim*, but in the central Adriatic, these species are rare (Šipoš, 1977).

The data on Mediterranean horse mackerel feeding habits in the Adriatic Sea are very poor. Bini (1968) and

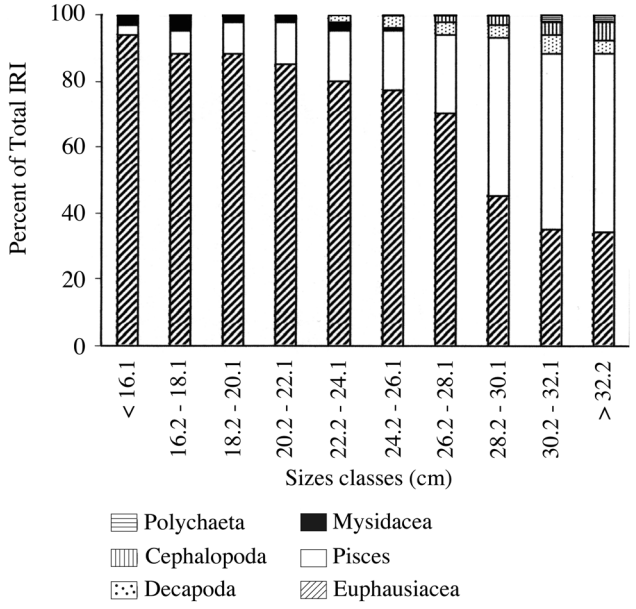

Figure 3. - Composition of *Trachurus mediteranneus* diet as a function of size, based on the % IRI values of the major prey groups.

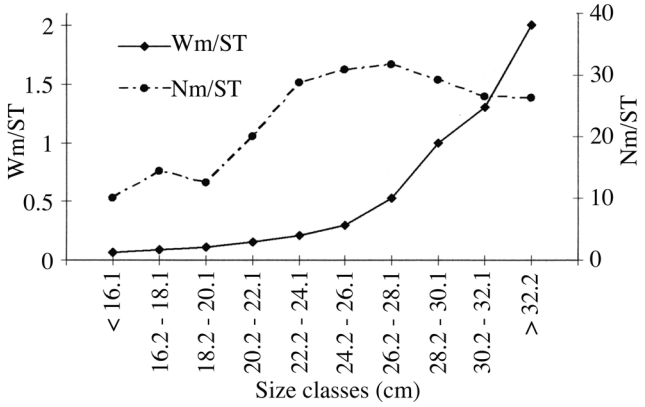

Figure 4. - Mean weight of prey per stomach (Wm/ST) and mean number of prey items per stomach (Nm/ST) as a function of *Trachurus mediteranneus* size.

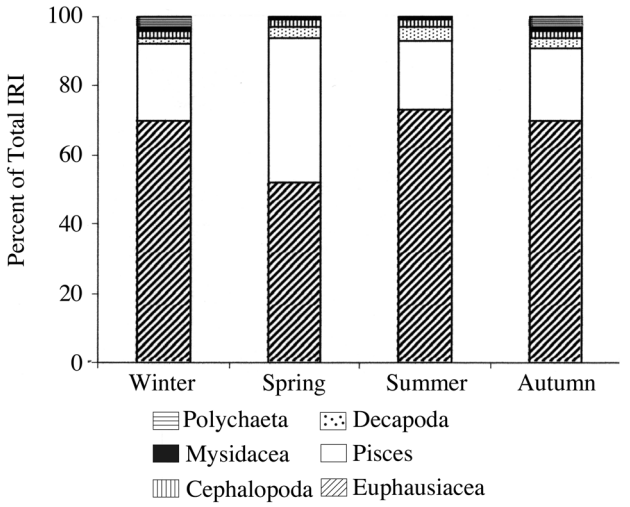

Figure 5. - Seasonal varation of *Trachurus mediteranneus* diet based on the %IRI values of the major prey groups.

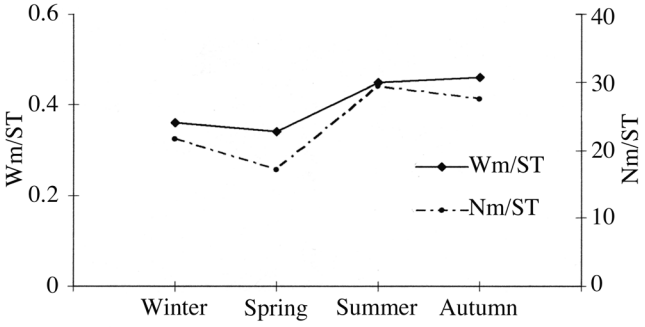

Figure 6. - Mean weight of prey per stomach (Wm/ST) and mean number of prey items per stomach (Nm/ST) of *Trachurus mediteranneus* through the year.

Tortonese (1975) gave general data mentioning only fish and small crustaceans as their food. In Albanian waters in summer period, these fish show preferences for different developmental stages of fish, particularly anchovy along with amphipod, mysid and decapod crustaceans (Lipskaja, 1966). In the Aegean Sea, larvae and postlarvae of fish (particularly *Pagellus acarne*, *Diplodus vulgaris* and *Spicara maena*) formed the dominant biomass (39.1%) in stomachs of *T. mediterraneus*, followed by copepod crustaceans (19.7%) and mysids (11.4%). The rest of stomach contents were made up by isopod, decapod and euphausiid crustaceans, cephalopods and tunicates (Kyrtatos, 1998). On the other hand, Ben-Salem (1988) reported Mysidacea, Euphausiacea, Isopoda and Amphipoda (%F = 71.4%) as main food items of *T. mediterraneus* from the Aegean Sea, while fish species were less abundant in analyzed specimens (%F = 14.2%). Mysidacea and Copepoda constitute a significant proportion of stomach contents in Lion Bay and Gascon Bay, while in Tunisian waters gobiids were the major prey (Ben-Salem,

1988). According to the above mentioned studies *T. mediterraneus* food is mainly dominated by pelagic and benthopelagic crustaceans and fish. The differences in food habits between Mediterranean parts and eastern Atlantic are mainly due to different distribution, abundance, density, and availability of the prey.

The data we obtained in this study show that food habits considerably change as fish grows. Smaller specimens mainly feed on planktonic euphausiid and mysid crustaceans that are abundant and have small weights. As fish grows the proportion of fish prey increases and that of euphausiids decreases. The mean prey weight (Wm/ST) significantly increases as a consequence of the presence of cephalopods, decapod crustaceans and polychaetae in addition to fish. Due to the smaller presence of euphausiid crustaceans the mean prey number per stomachs (Nm/ST) is reduced in the largest size classes. Data obtained in this study on the changes of food content are consistent with those of Kyrtatos (1998) and Lipskaja (1966). Namely, Kyrtatos (1998) reported that smaller specimens of *T. mediterraneus* (up to 20.0 cm in length) from the Aegean Sea consume more mysids and copepods, while with the increase in length they switch larval and postlarval fish stages. Lipskaja (1966) also stated that the stomachs of smallest specimens contained mostly copepods, and those of larger ones predominantly larval and postlarval anchovy (*Engraulis encrasicolus*). There is evidence that size differences reflect changing food preference with growth and the ability of large individuals to capture larger prey. Mean prey size increases with increasing predator size in order to optimize the energy per unit effort (Ware, 1972; Ross, 1977; Stoner and Lingviston, 1984). Trophic ontogeny in Mediterranean horse mackerel could be explained in terms of fish morphology. The width and gape of mouth are linearly related to the fish size (Ross, 1978; Stoner, 1980) and increased body and mouth size permit fish to capture a broader range of prey size and prey types. Such changes in food habits with fish size could decrease intraspecific competition (Langton, 1982).

Feeding intensity is negatively related to the percentage of empty stomachs (Bowman and Bowman, 1980). In this study feeding intensity of the *T. mediterraneus* increased with growth, so that highest values of emptiness were recorded from smallest length classes. This is in disagreement with the general statements that a higher feeding frequency is more pronounced in smaller individuals (Growe and Crawford, 1980; Chapman *et al*., 1988). However, smaller prey items (*i.e*. euphausiids and mysids) are digested faster than largest prey found in the diet of large size fish.

Feeding intensity significantly changes with respect to seasonal cycle and it is a probable reason why relatively high stomach emptiness (50.5%) was recorded during our study period. The highest values of stomach emptiness were recorded in the winter (VI = 66.0%). Poorer feeding intensity in winter is probably related to lower sea water temperatures which slowly down the metabolism, and thereby further results in reduced feeding. This assumption may be confirmed by the values of mean weight (Wm/ST) and mean number (Nm/ST), which were highest in summer-autumn, and were decreasing in winter-spring periods. Intensified feeding extends throughout summer probably due to higher temperatures, which stimulate metabolism and increase food demands. In addition, *Trachurus mediterraneus ponticus* from the Black sea shows poor feeding intensity in winter, which intensifies in spring by 70.0% with the rise of sea water temperature (Sirotenko and Istomin, 1978). In our study food content of *T. mediterraneus* showed no seasonal variations. The euphausiid crustaceans dominated in the diet throughout the year, whereas fish constituted a significant part in spring. This is probably due to the fact that euphausiid crustaceans are present in the Adriatic study area all year round. Their density being highest from autumn to spring when they are most frequently present in plankton samples (Šipoš, 1977; Gamulin, 1979).

REFERENCES

ARNERI E., 1984. - Note preliminare sulla biologia delle specie del *Trachurus* (*Trachurus trachurus, Trachurus mediterraneus, Trachurus picturatus*) in Adriatico. *Nova Thallas*., 6: 459-464.

ARNERI E. & P. TANGERINI, 1984. - Biological data collected during the Pipeta expeditions on *Trachurus mediterraneus* (Steindachner) in the Adriatic Sea. *FAO Fish. Rep*., 290: 127-130.

BEN-SALEM M., 1988. - Régime alimentaire de *Trachurus trachurus* (Linnaeus, 1758) et de *Trachurus mediterraneus* (Steindachner, 1868) (Poissons, Téléostéens, Carangidae) de la province Atlantico-Méditerranéenne. *Cybium*, 12: 247-253.

BERG J., 1979. - Discussion of the methods of investigating the food of fishes with reference to a preliminary study of the food of *Gobiusculus flavescens* (Gobidae). *Mar. Biol*., 50: 263-273.

BINI G., 1968. - Atlante dei Pesci delle Coste Italiane, Vol V. Osteitti. 175 p. Milano: Mondo Sommerso Editrice.

BOWMAN R.E. & E.W. BOWMAN, 1980. - Diurnal variation in the feeding intensity and catchability of silver hake (*Merluccius bilinearis*). *Can. J. Fish. Aquat. Sci*., 37: 1565-1572.

CHAPMAN L.J., MACKAY W.C. & C.W. WILKINSON, 1988. - Feeding flexibility in northeren pike (*Esox lucius*): Fish versus invertebrate prey. *Can. J. Fish. Aquat. Sci*., 46: 666-669.

COUSSEAU M.B., 1967. - Contribución al conocimiento de la biologia del surel (*Trachurus picturatus australis*) del ârea de Mar del Plata (Pises, Fam. Carangidae). *Biol. Inst. Biol. Mar*., *Argentina*, 15: 1-38.

FAO yearbook, 2000. - Fishery Statistics. Capture Production. Vol. 86/1, 713 p. Rome: FAO.

GAMULIN T., 1979. - Zooplankton of the eastern Adriatic coast. *Acta Biol*., 8: 177-270.

GROWE D. & C. CRAWFORD, 1980. - Correlation between digestion rate and feeding frequency in stomachless teleost *Blennius pholis* L. *J. Fish Biol*., 16: 235-247.

HACUNDA J.S., 1981. - Trophic relationships among demersal fishes in coastal area of the Gulf of Main. *Fish. Bull*., 79: 775-788.

HECHT T., 1990. - On the life history of cape horse mackerel *Trachurus trachurus capensis* off the south-east coast of south Africa. *S. Afr. J. Mar. Sci*., 9: 317-326.

HOENIGMAN J., 1963. - Mysidacea de l'expédition "Hvar" dans l'Adriatique. *Rapp. Comm. Int. Mer Médit*., 17: 603-616.

HYSLOP E.J., 1980. - Stomach contents analysis - A review of methods and their application. *J. Fish Biol*., 17: 411-429.

JARDAS I., 1996. - The Adriatic Ichthyofauna. 553 p. Zagreb: Školska knjiga d.d.

JUKIĆ S., 1978. - Contribution to the knowledge of the relationship between formation of deep scattering layer (DSL) and biological components in the central Adriatic. *Acta Adriat*., 19: 1-17.

KARLOVAC O., 1959. - La nourriture du merlu (*Merluccius merluccius* L.) de la mer Adriatique. *Rapp. P.-V. Réun. CIESMM*, 5: 333-339.

KONCHINA Y.V., 1981. - The feeding of the Peruvian jack mackerel, *Trachurus symetricus murphyi*. *J. Ichtyol*., 19: 52-60.

KYRTATOS N.A., 1998. - Contribution à la connaissance de la nourriture de *Trachurus mediterraneus* (Steind.) et de son influence sur les chaînes alimentaires de la Mer Égée centrale. *Rapp. Comm. Int. Mer Médit*., 35: 452-453.

LANGTON R.W., 1982. - Diet overlap between Atlantic cod, *Gadus morhua*, silver hake *Merluccius bilinearis* and fifteen other northwest Atlantic finfish. *Fish. Bull*., 80: 745-759.

LIPSKAJA N.J., 1966. - Pitanie stavridy (*Trachurus mediterraneus* Steind.) v Adriatičeskom i Černom morjah. Issledovania planktona južnyh morej. *Nauka*, 210: 109-114.

NOŽINA I., 1979. - Biogenic deep scattering layers in the Adriatic mesopelagial. 151 p. PhD. Thesis, Univ. Ljubljana.

OLASO I., CENDERERO O. & P. ABAUNZA, 1999. - The diet of the horse mackerel, *Trachurus trachurus* (Linnaeus, 1758), in the Cantabrian Sea (north Spain). *J. Appl. Ichthyol.,* 15: 193-198.

PINKAS L., OLIPHANT M.S. & I.L.K. IVERSON, 1971. - Food habits of albacore, bluefin tuna and bonito in California waters. *Fish. Bull*., 152: 1-105.

ROSECCHI E. & Y. NOUAZE, 1987. - Comparaison de cinq indices alimentaires utilisés dans l'analyse des contenus stomacaux. *Rev. Trav. Inst. Pêch. Marit*., 49: 111-123.

ROSS S.T., 1977. - Patterns of resource partitioning in searobins (Pisces: Triglidae). *Copeia*, 1977: 561-571.

ROSS S.T., 1978. - Trophic ontogeny of the leopard searobin, *Prinotus scitulus* (Pisces: Triglidae). *Fish. Bull*., 76: 225-234.

SMITH-VANIZ W.F., 1986. - Carangidae. *In:* Fishes of the Northeastern Atlantic and Mediterranean, Vol II (Whitehead P.J.P., Bauchot M.-L., Hureau J.-C., Nielsen J. & E. Tortonese, ed.), pp. 815-844. Paris: UNESCO.

SIROTENKO M. & A. ISTOMIN, 1978. - Seasonal variations in the feeding of the Black Sea *Trachurus mediterraneus ponticus* Aleev. *J. Ichthyol*., 18: 424-431.

SOKAL R.R. & F.J. ROLF, 1981. - Biometry: The Principles and Practices of Statistics in biological Research. 636 p. San Francisco: Freemen.

STONER A.W., 1980. - Feeding ecology of *Lagodon rhomboides* (Pisces: Sparidea): Variation and functional response iatic sea in autumn 1974 and spring 1975. *Rapp. Comm. Int. Mer Medit*., 24: 10-11.

TORTONESE E., 1975. - Osteichthyes (Pesci ossei). Vol. II. Fauna d'Italia, 11. 636 p. Bologna: Calderini.

VRGOČ N., 2000. - Structure and dynamics of demersal fish communities of the Adriatic Sea. 197 p. Ph.D. Thesis. Univ. Zagreb (mimeo).

WARE D., 1972. - Predation by rainbow trout (*Salmo gairdneri*) the influence of hunger, prey density and prey size. *J. Fish. Res. Bd. Can*., 29: 1193-1201.

ZAR J.H., 1984. - Biostatistical Analysis. 718 p. Prentice-Hall, Englewood Cliffs.

ŽUPANOVIĆ Š., 1968. - Study of hake (*Merluccius merluccius* L.) biology and population dynamics in the central Adriatic. *FAO Stud. Rev*., 32: 1-24.

Reçu le 12 juillet 2002.
Accepté pour publication le 05 mai 2003.